

## LA-UR-21-30422

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Title: RCT 4th Qtr Continuing Training- Radiological Surveys

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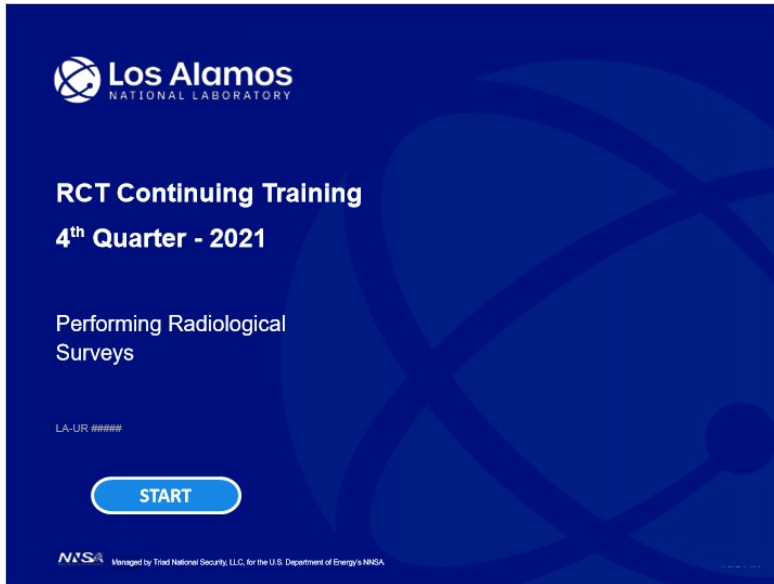
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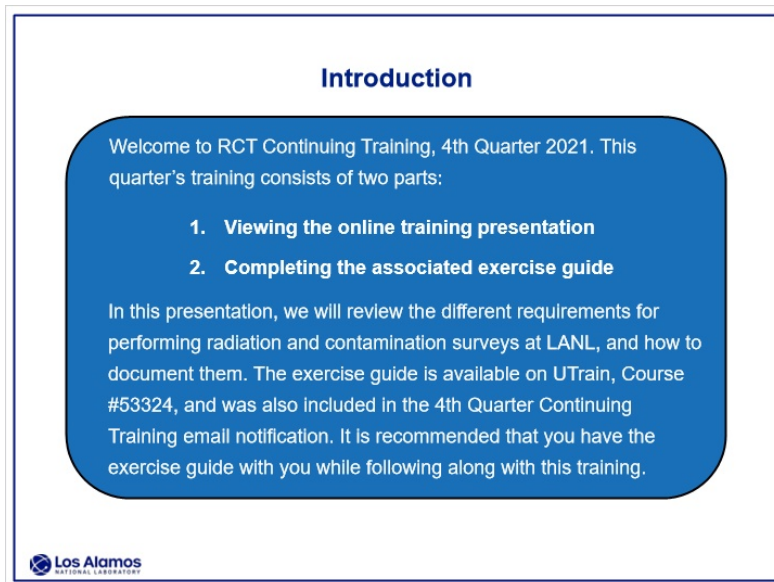
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# 1. RCT Continuing Training 4th Quarter 2021

## 1.1 RCT Continuing Training



## 1.2 Introduction



Notes:

### 1.3 Terminal Objectives

#### Terminal Objectives

- TO1: Given the need to perform radiation surveys, recognize the requirements of an RCT in accordance with P121, *Radiation Protection* and RP-PROG-TP-200, *Radiation Protection Manual*.
- TO2: Given the need to perform contamination surveys, recognize the requirements of an RCT in accordance with P121, *Radiation Protection* and RP-PROG-TP-200, *Radiation Protection Manual*.



### 1.4 Enabling Objectives

#### Enabling Objectives

- EO1: Identify how to perform Shallow Dose Evaluations (SDE)
- EO2: Calculate the Sum of All Radiation (SAR)
- EO3: Explain how to perform radiation surveys
- EO4: Explain how to perform contamination surveys
- EO5: Discuss how to perform field screens of contamination smears
- EO6: Demonstrate documenting radiological surveys





## 1.5 Radiological Surveys

### Radiological Surveys

Radiation and contamination monitoring is the foundation for a strong RP Program. A thorough understanding of radiological surveys serves as the basis for other tasks such as item release and job coverage. Inadequate surveys lead to:

- Release of radioactive material to the public
- Personnel contamination events
- Radiological posting violations
- Over-exposure incidents

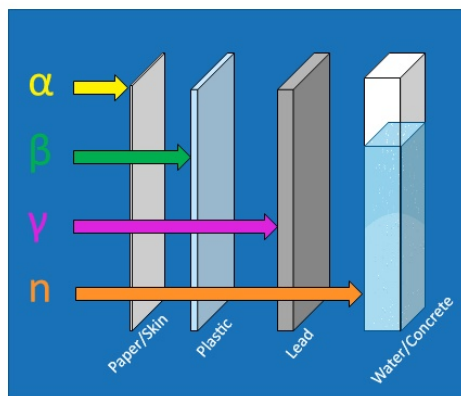
As an RCT, it is your responsibility to not only know how to perform these surveys, but to also process and understand the information being observed.



Notes:

## 1.6 Radiological Characteristics Review

### Radiological Characteristics Review



Prior to performing surveys, an RCT should understand the fundamentals of radiation and how it interacts with matter. Understanding the fundamentals allows RCTs to better recognize what is being surveyed and gives them the ability to anticipate changes.

Before we go over how to conduct radiological surveys, let's review the different radiological characteristics of alpha, beta, gamma, and neutron radiation.



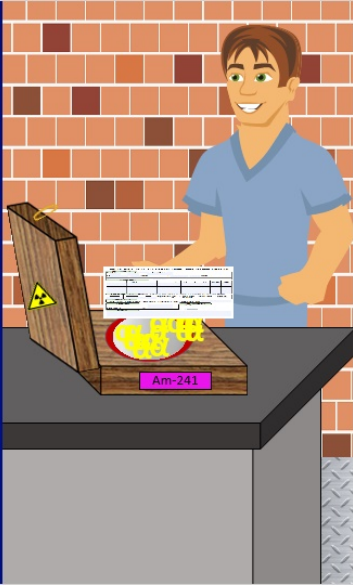
## 1.7 Alpha Radiation

### Alpha Radiation

A positive particle consisting of two protons and two neutrons (He-4). Alphas are typically produced from heavy nuclei reactions (i.e. plutonium). Alphas do not pose a significant external radiation hazard due to their ability to be shielded and low travel distances.

Shielding Characteristics	Range in Air
Thin amounts of most any material (paper, unbroken dead cell layer of skin)	~ 1 – 3 cm

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The illustration shows a male scientist in a blue lab coat standing behind a grey counter. On the counter is a wooden box with a yellow radiation warning symbol and a label that reads 'Am-241'. A small white card with text is also on the counter. The background is a brick wall.

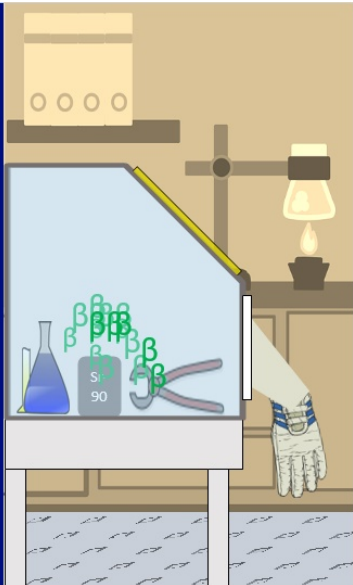
## 1.8 Beta Radiation

### Beta Radiation

Charged, fast-moving electrons or positrons. These are produced from the nucleus of unstable isotopes (Cs-137, Sr-90). Betas have longer range than alphas, but cause less internal biological damage compared to alpha radiation. High energy beta radiation can potentially create skin burns.

Shielding Characteristics	Range in Air
Low Z and low density materials. (Plastic, aluminum, rubber)	~ 4 meters / MeV

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The illustration shows a scientist in a lab coat and gloves using tongs to handle a radiation source labeled 'Sr-90' inside a lead shield. The shield is a large, light blue rectangular block. The scientist is standing behind a counter. In the background, there is a lamp and a container with three circles.

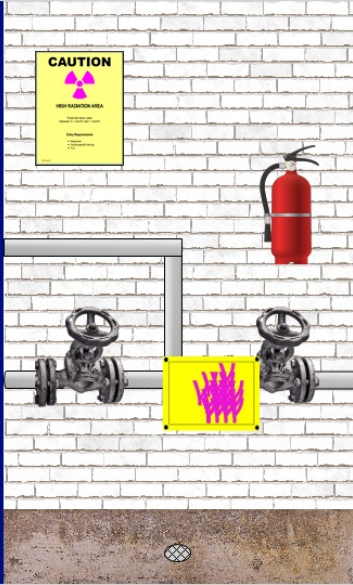
## 1.9 Gamma Radiation

### Gamma Radiation

Gamma radiation, sometimes referred to as high energy photons, are fast-moving packets of high-energy radiation with no mass or charge. Due to their absence of mass and charge, gammas have an extremely long range in air (Co-60, I-131). They cause significant risk to produce biological damage.

Shielding Characteristics	Range in Air
High Z and high density material (Lead, depleted Uranium)	Hundreds of meters

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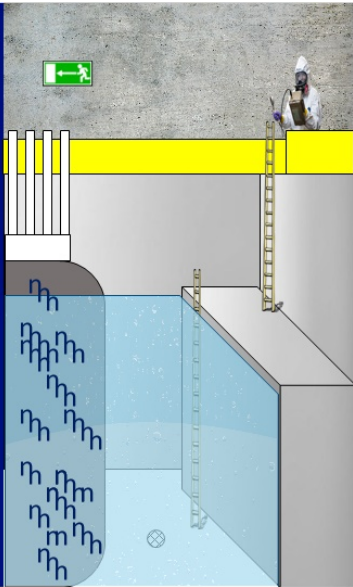
## 1.10 Neutron Radiation

### Neutron Radiation

Free traveling, thermal, slow, or fast neutrons that can be produced from nuclear fission. Neutron radiation can travel great distances in air, with a high penetrating ability. Neutrons are the only type of radiation that can cause materials to become radioactive, known as neutron activation.

Shielding Characteristics	Range in Air
Hydrogenous material for moderation (water) and capture material of absorption (boron).	Hundreds - thousands of meters

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## 1.11 Lesson Learned Summary

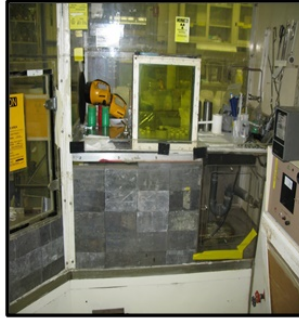
### Lesson Learned: UNPLANNED EXTREMITY DOSE FROM RADIOACTIVE SAMPLE

#### Event:

Poor work planning, inadequate response to dose rate reading discrepancies, and departures from work control documents resulted in unplanned extremity exposure to three workers.

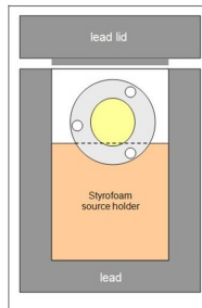
#### Summary:

In July 2009, a sample containing Arsenic (As)-73 (gamma emitter) and As-74 (beta + gamma emitter) prepared in the Hot Cell facility at TA 48 Building 1 was removed from the facility shielding and placed behind shielded glass on the dilution bench to be decontaminated and packaged for shipping to TA-53.



## 1.12 Summary 2 of 4

- The hazards and controls established for the source were as documented in the existing IWD and were expected to be the same as other sources routinely worked with in the hot cell area.
- However, the source created a highly directional source of beta radiation and was not contained in solution, as is normally required per the IWD.
- The change in hazard was not recognized by all participants in the work activity.
- The initial dose rate measured as the sample emerged from the Hot Cells at TA-48 was 4 R/hr at 30 cm, within the RWP limit of 5 R/hr at 30 cm.



The As-73/As-74 titanium/aluminum source disk in lead shielding container.



### 1.13 Summary 3 of 4

- The lead chemist placed it in the lead shipping pig, where another dose rate reading at the mouth of the pig indicated 30 R/hr at 30 cm.
- Although the sample was packaged safely for shipping this dose rate discrepancy was not fully documented.
- The sample was shipped to TA-53 where the container and the lead pig holding the sample were surveyed for dose rate and contamination.
- The contamination survey was negative and the external dose rate survey with the pig lid open indicated 5 R/hr beta/gamma and 1 R/hr gamma at 30 cm.

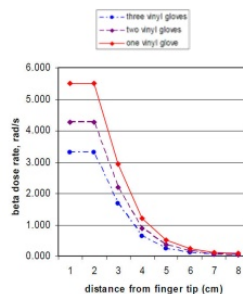


Using tweezers to position As-73/As-74 titanium/aluminum source disk onto the three posts.



### 1.14 Summary 4 of 4

- The gamma dose rate was within the RWP limits at TA-53 (beta dose rate limit was not defined) and the work team proceeded with mounting the sample in the ion chamber.
- As the mounting process neared completion, another dose rate measurement indicated 30 R/hr at 30 cm.
- The work team members agreed that to make the situation safe while minimizing additional exposure, the mounting should be completed and the ion chamber cover put in place.
- Two researchers received doses to their extremities while installing the sample and assembling the ion chamber. A subsequent dose assessment indicated beta doses of 26 rem and 19 rem to the extremities.



Dose rate to index finger while holding source






## 1.15 What Caused This to Occur?

### What Caused This to Occur?

Contributing Factors	Preventative Actions
<ul style="list-style-type: none"><li>• Inadequate work planning</li><li>• RWP discrepancies between the different facilities handling the source</li><li>• Insufficient response to dose rate discrepancies</li><li>• Not enough communication from SMEs and RCTs</li><li>• Lack of a questioning attitude</li></ul>	<ul style="list-style-type: none"><li>• Use of a job specific RWP</li><li>• Work control documents should be coordinated or cross examined to ensure consistency</li><li>• Concerns are raised when RWP violations are discovered</li><li>• Clear communications between all work groups must be established</li><li>• Critical thinking</li></ul>

[Click here to view the full lessons learned report](#)



## 1.16 Radiological Survey Types and Documentation




### Radiological Survey Types and Documentation


To complete this training you will need to go through the radiation, contamination, and documenting surveys sections of the lesson. After completing radiation and contamination surveys, proceed to the documenting surveys portion.

Radiation Surveys

Contamination Surveys

Documenting Surveys








## 2. Radiation Surveys

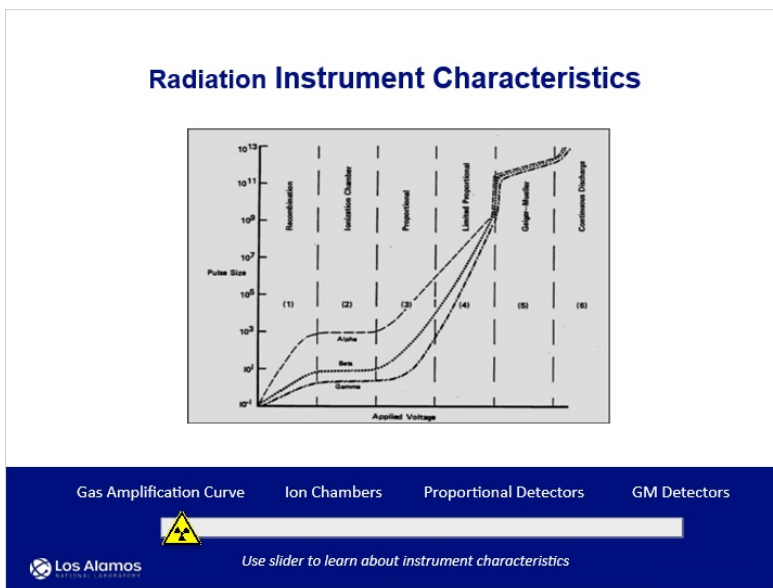
### 2.1 Performing Radiation Surveys

**Performing Radiation Surveys**

Radiation surveys are necessary to determine dose rates of specific material, objects, and locations. As an RCT, it is your job to process this information and take appropriate actions as required by LANL RP procedures. Types of responses may include pausing/stopping a job, changing a radiological posting, having workers move to a different location, or notifying an HPFC on trending dose rates. Being able to analyze the readings on your instrumentation can help prevent radiological incidents from occurring.



### 2.2 Instrument Characteristics



Notes:

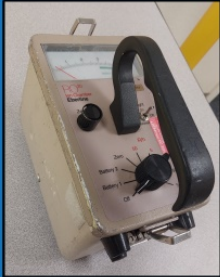


## Ion Chamber (Slide Layer)

### Ion Chambers

#### Advantages

- Less expensive and more portable power supplies can be used with ion chamber instruments
- The ion chamber response is directly proportional to the dose rate
- An air-filled ion chamber when used for photon radiation, yields the true exposure rate



#### Disadvantages


- The sensitivity of a small ion chamber is very poor because a few ionizing events per minute do not create sufficient currents to be measured
- Humidity can cause an effect on the readings
- Changes in altitude and temperature can cause inaccurate readings


Gas Amplification Curve

Ion Chambers

Proportional Detectors

GM Detectors




 *Use slider to learn about instrument characteristics*

## Proportional (Slide Layer)

### Proportional Detectors

#### Advantages

- Can be used to discriminate against different types of radiation
- The output signal is larger, therefore has more sensitivity
- Output signal is proportional to the energy deposited by ionization and therefore proportional to the dose rate



#### Disadvantages


- A proportional counter is sensitive to high voltage changes because of the effect on the gas amplification factor
- More highly regulated power supplies are necessary for proportional counters

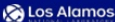
Gas Amplification Curve

Ion Chambers

Proportional Detectors

GM Detectors




 *Use slider to learn about instrument characteristics*

## Geiger Mueller (Slide Layer)

### Geiger-Mueller

#### Advantages

- GM detectors are generally more sensitive to low energy and low intensity radiations than air proportional or ion chamber detectors
- Not affected by temperature and pressure
- Require less highly regulated power supplies



#### Disadvantages


- GM detector response is not related to the energy deposited; therefore GM detectors can not be used to directly measure true dose, as can be done with an ion chamber instrument
- Cannot discriminate against different types of radiation

Gas Amplification Curve


Ion Chambers

Proportional Detectors

GM Detectors



Use slider to learn about instrument characteristics



## 2.3 Instruments Used at LANL


### Radiation Detection Instruments Used at LANL

Using the correct instrument for the job is essential while performing radiation surveys. This was demonstrated in the lessons learned by not accounting for the beta contributions.

When choosing an instrument, determine the types of radiation expected in the area. There may be times where multiple detectors are necessary for the job.

An RCT should also have an understanding on how their instrument works and any limiting conditions that may come along with it.

Radiation	Instrument
Gamma/X-ray	RO-20 Micro-Rem Teletector (non-quantifiable)
Beta	RO-20 (open window)
Neutron	E-600/NRD RadEye PX/NRD ESP/NRD



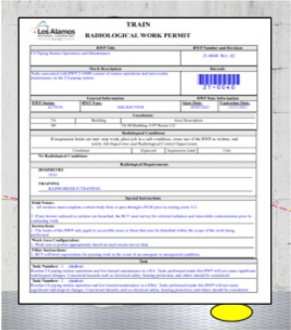
## 2.4 External Radiation Surveying Requirements

### External Radiation Surveying Requirements

**RP-PROG-TP-200, Section 1521**

Conduct external radiation surveys:

- Before, during, and after work that involved the potential for significant changes in the levels of radiation
- Upon entry into an HRA
- For initial posting or posting changes
- To support work, including RMLs, RWP hold points, etc.
- As requested



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## 2.5 External Radiation Surveying Requirements continued

### External Radiation Surveying Requirements

**Conduct additional external radiation surveys:**


- When a source has been exposed and then secured or shielded to verify that the very high radiation field has been terminated
- When a radiation generating device (RGD) has been de-energized to verify that the high or very high radiation field has been terminated
- Whenever personnel may be exposed to small intense beams of radiation, such as those generated by unshielded x-ray devices
- When surveying in contaminated areas, take steps to prevent contamination of the survey instrument (e.g., by placing the instruments in plastic bags)
- If performing an external radiation survey in an HRA or VHRA, then ensure required instrument checks are conducted prior to entry

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## 2.6 Distances for External Radiation Surveys

**Distances for External Radiation Surveys**

General Area	30 cm	On-contact
General area surveys are taken at distances approximately three feet above the floor. These are the most common types of surveys an RCT will take. The GA readings can be used to help determine RWP limits, stay-times, and expected dose received for specific jobs.	Performing radiation surveys at a distance of 30 centimeters is required when posting an RA or HRA. These readings can also be helpful when determining work area dose rates near an object, such as piping or a valve. Similar to on-contact readings, these are required for HPRMS tags.	An on-contact survey is needed when hands-on work is being conducted with radioactive material. HPRMS tags also require an on-contact reading to be performed. This survey is an effective method in finding small localized areas of radiation.




Notes:

## 2.7 Knowledge Check

(Drag and Drop, 0 points, 2 attempts permitted)

**Drag and Drop Items to Correct Detector Type**

Ion Chambers	Geiger-Mueller	Proportional
Yields true exposure rate	Inexpensive/portable	Sensitive to low energy
Discriminate radiation types	Affected by humidity	Altitude alters readings
Not used to measure true dose rate	Sensitive to high voltage changes	Cannot discriminate radiation types
Not affected by pressure and temperature	Needs highly regulated power supply	Proportional to dose rate

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Drag Item	Drop Target
Inexpensive/portable	IC
Affected by humidity	IC
Altitude alters readings	IC
Yields true exposure rate	IC
Discriminate radiation types	Prop
Needs highly regulated power supply	Prop
Not affected by pressure and temperature	GM
Sensitive to high voltage changes	Prop
Proportional to dose rate	Prop
Sensitive to low energy	GM
Cannot discriminate radiation types	GM
Not used to measure true dose rate	GM

Drag and drop properties
Return item to start point if dropped outside the correct drop target
Snap dropped items to drop target (Tile)
Delay item drop states until interaction is submitted

**Feedback when correct:**

That's right! You selected the correct response.

**Feedback when incorrect:**

You did not select the correct response.

### Correct (Slide Layer)

**Drag and Drop Items to Correct Detector Type**

Correct

That's right! You selected the correct response.

Continue

Ion Chamber      Proportional

Yields true dose rate      Not affected by low energy

Discriminate radiation types	Affected by humidity	Altitude alters readings
Not used to measure true dose rate	Sensitive to high voltage changes	Cannot discriminate radiation types
Not affected by pressure and temperature	Needs highly regulated power supply	Proportional to dose rate

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### Incorrect (Slide Layer)

**Drag and Drop Items to Correct Detector Type**

Incorrect

You did not select the correct response.

Continue

Ion Chamber      Proportional

Yields true dose rate      Not affected by low energy

Discriminate radiation types	Affected by humidity	Altitude alters readings
Not used to measure true dose rate	Sensitive to high voltage changes	Cannot discriminate radiation types
Not affected by pressure and temperature	Needs highly regulated power supply	Proportional to dose rate

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## Try Again (Slide Layer)

**Drag and Drop Items to Correct Detector Type**

Incorrect

That is incorrect. Please try again.

Try Again

Ion Chambers	Geiger-Mueller	Proportional
Yields true exposure rate Inexpensive/portable Affected by humidity Altitude alters readings	Sensitive to low energy Not used to measure true dose rate Cannot discriminate radiation types Not affected by pressure and temperature	Sensitive to high voltage changes Needs highly regulated power supply Discriminate radiation types Proportional to dose rate

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## 2.8 Knowledge Check Answer

**Correct Answer**

Yields true exposure rate Inexpensive/portable Affected by humidity Altitude alters readings	Sensitive to low energy Not used to measure true dose rate Cannot discriminate radiation types Not affected by pressure and temperature	Sensitive to high voltage changes Needs highly regulated power supply Discriminate radiation types Proportional to dose rate
Ion Chambers	Geiger-Mueller	Proportional

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## 2.9 RO-20 Contact External Radiation Surveys

### RO-20 Contact External Radiation Surveys

#### RP-PROG-TP-200, Section 1521.4

- If a contact dose rate for DU is required, then calculate the OW in mrem/hr using the following equation:

$$\text{Corrected OW (mrem/hr)} = \text{OW (mR/hr)} \times 3$$

OW = Open window reading on contact (mR/hr)    3 = DU contact beta correction factor

- If the contact reading does not involve DU, then contact the facility Health Physicist (HP) for a correction factor.
- If no correction is provided by the HP, then only record the uncorrected OW value in mR/hr.



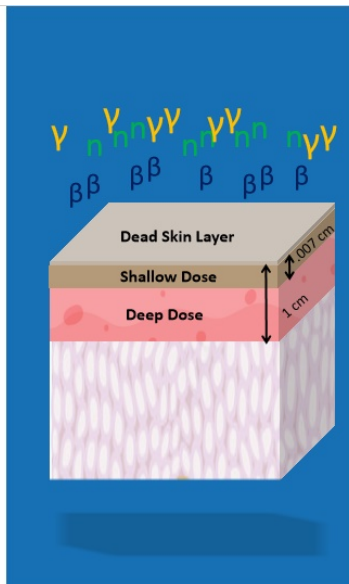
## 2.10 Shallow Dose Evaluations

### Shallow Dose Evaluations

Shallow dose refers to the exposure received in living tissue, just below the dead layer of skin, at 7-mg/cm<sup>2</sup>. This dose, as well as deep dose exposure (1000-mg/cm<sup>2</sup>) are used to determine the Sum of All Radiations (SAR).

RCTs need to be aware of how and when to perform this type of survey. Failure to account for shallow dose can lead to possible posting violations or over exposure events.

We will review when this type of survey is procedurally required to be taken, and the method to perform them.





## 2.11 When to Perform SDEs

### When to Perform Shallow Dose Evaluations

#### RP-PROG-TP-200, Section 1521.2 *Shallow Dose Evaluations*

- An evaluation of shallow dose contribution to the total radiation dose must be performed in the following situations:
  - Characterization surveys for new radioactive material activities or areas
  - Re-characterization surveys for a radioactive material area/activity when changes have occurred in radioactive material type, quantity, configuration, location, or shielding
  - Posting surveys
- A shallow dose evaluation is not required to be calculated for area/activity surveys once a ratio for that area/activity has been established in a characterization survey, unless changes have occurred.



## 2.12 How to Perform a SDE

### How to Perform a SDE

Shallow dose evaluations shall be performed with an RO-20 ion chamber open and closed window readings.

Divide the open window (OW) reading by the closed window (CW) reading to obtain an OW/CW ratio.

- IF the OW/CW ratio is  $\geq 1.2$ , then beta radiation must be included in Sum of All Radiation (SAR) calculations for the area/activity surveys
- IF the OW/CW ratio is  $< 1.2$ , then beta radiation is not included in SAR calculations (only closed window RO-20 readings are used)



## 2.13 SAR Equations

### Sum of All Radiations (SAR) Equations

- IF the OW/CW ratio is  $< 1.2$ , then calculate the SAR using:

$$\text{SAR} = \underset{\substack{\uparrow \\ \gamma}}{\text{CW}} + \underset{\substack{\uparrow \\ n}}{\text{NDR}}$$

- IF the OW/CW ratio is  $\geq 1.2$ , then calculate the SAR using:

$$\text{SAR} = \underset{\substack{\uparrow \\ \beta}}{[(\text{OW}-\text{CW}) \times 2.5]} + \underset{\substack{\uparrow \\ \gamma}}{\text{CW}} + \underset{\substack{\uparrow \\ n}}{\text{NDR}}$$

OW = Open window reading (mR/hr)

NDR = Neutron Dose Rate (mrem/hr)

CW = Closed window reading at (mR/hr)

SAR = Sum of All Radiations (mrem/hr)

2.5 = RO-20 beta correction factor



## 2.14 OW/CW < 1.2 Example

### OW/CW < 1.2 Example

CW Reading = 1.2 mR/hr @ 30 cm

OW Reading = 1.3 mR/hr @ 30 cm

Neutron Reading = 2.2 mrem/hr



$$\text{OW/CW} = 1.3 / 1.2 = 1.08$$

$$1.08 < 1.2$$

$$\text{SAR} = \text{CW} + \text{NDR}$$

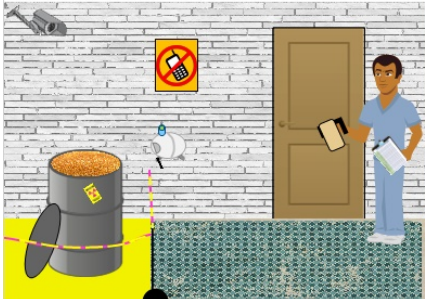
$$\text{SAR} = 1.2 + 2.2 \text{ (mrem/hr)}$$

$$\text{SAR} = 3.4 \text{ mrem/hr}$$

## 2.15 OW/CW > 1.2 Example

**OW/CW  $\geq 1.2$  Example**

CW Reading = 18 mR/hr @ 30 cm  
OW Reading = 26 mR/hr @ 30 cm  
Neutron Reading = 8 mrem/hr



$OW/CW = 26/18 = 1.44$

$1.44 > 1.2$

$SAR = [(OW-CW) \times 2.5] + CW + NDR$

$26 - 18 = 8$

$8 \times 2.5 = 20$

$SAR = 20 + 18 + 8 \text{ (mrem/hr)}$


$SAR = 46 \text{ mrem/hr}$

## 2.16 SAR Applications


**SAR Applications**

Determining the Sum of All Radiations is necessary for:

- Establishing postings
- Radioactive material shipments
- General area dose rates
- Work area dose rates
- Down-posting surveys
- Dose investigations



Failure to account for all sources of radiation, such as beta dose or neutrons, can lead to inaccurate results and regulatory violations. RCT's must have an understanding of the radiological conditions they are working in, and always have a questioning attitude to ensure violations do not occur.



## 2.17 Radiation Limits of Concern

### Radiation Limits of Concern

The Sum of All Radiations is used for posting classifications at LANL. Table 7-3 in P121 lists the criteria for posting external radiation hazards, as shown here.

Area	Criteria
Radiation Area	$\geq 5$ mrem/hr – $< 100$ mrem/hr @ 30 cm
High Radiation Area (Caution)	$\geq 100$ mrem/hr – $< 1,000$ mrem/hr @ 30 cm
High Radiation Area (Danger)	$\geq 1,000$ mrem/hr @ 30 cm
Very High Radiation Area	$> 500$ rad/hr @ 100 cm



## 2.18 Knowledge Check

(Multiple Choice, 0 points, unlimited attempts permitted)

A radiation survey is performed on an object. The readings are 25 mR/hr at 30 cm open window, 19 mR/hr at 30 cm closed window, and 10 mrem/hr at 30 cm for neutron radiation. What is the Sum of All Radiation?

- ☐ 29
- ☐ 35
- ☐ 15
- ☒ 44



Correct Choice

29

	35
	15
X	44

**Feedback when correct:**

That's right! You selected the correct response.

$$25/19 > 1.2$$

$$[(25-19)2.5] + 19 + 10$$

$$= 44 \text{ mrem/hr}$$

**Feedback when incorrect:**

You did not select the correct response.

**Correct (Slide Layer)**

A radiation survey is performed on an object. The readings are 25 mR/hr at 30 cm open window, 19 mR/hr at 30 cm closed window, and 10 mrem/hr at 30 cm for neutron radiation. What is the Sum of All Radiation?

**Correct**

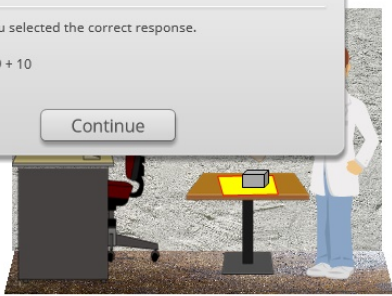
That's right! You selected the correct response.

$25/19 \geq 1.2$

$[(25-19)2.5] + 19 + 10$

$= 44 \text{ mrem/hr}$

Continue



44

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### Incorrect (Slide Layer)

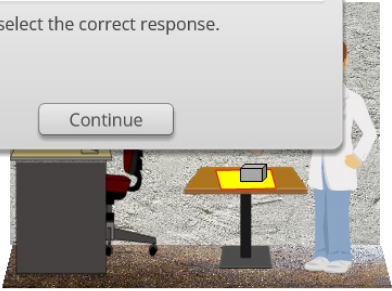
A radiation survey is performed on an object. The readings are 25 mR/hr at 30 cm open window, 19 mR/hr at 30 cm closed window, and 10 mrem/hr at 30 cm for neutron radiation. What is the Sum of All Radiation?

**Incorrect**

You did not select the correct response.

Continue

44



### Try Again (Slide Layer)

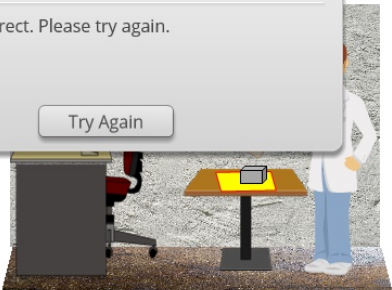
A radiation survey is performed on an object. The readings are 25 mR/hr at 30 cm open window, 19 mR/hr at 30 cm closed window, and 10 mrem/hr at 30 cm for neutron radiation. What is the Sum of All Radiation?

**Incorrect**

That is incorrect. Please try again.

Try Again

44






## 3. Contamination Surveys

### 3.1 Performing Contamination Surveys

**Performing Contamination Surveys**

Contamination is defined as radioactive material in an unwanted location. Surveys are performed to detect and quantify contamination on an object. These are required for situations such as monitoring personnel and items out of Radiological Controlled Areas, shipping of radioactive material, job coverage, and much more. RCTs are expected to know the requirements of when and how to properly perform contamination surveys. Understanding LANL procedures and radiological principles will help achieve this.

An illustration of a contamination survey in progress. A female technician in a white lab coat and blue pants is using a handheld detector on a black rectangular object held by a male worker in a grey shirt and brown pants. Another male worker in a grey shirt and brown pants stands near a large piece of equipment. The background shows a brick wall with a yellow 'NOTICE' sign, a bulletin board, and a water cooler. A yellow and black striped barrier is in the foreground.

### 3.2 Contamination Control General Requirements

**Contamination Control General Requirements**

**Radiological Control Technicians**


- Perform contamination surveys in accordance with RP-PROG-TP-200 and associated procedures
- Monitor work operations to prevent the spread of contamination into areas that are outside radiological control boundaries
- Complete surveys as soon as practical, but no later than one working day after results are available
- Notify the HPFC and appropriate facility personnel of any unusual survey results or conditions

A photograph showing a large, modern industrial facility with a prominent curved bridge structure. The facility is surrounded by trees and greenery. A green bus is visible on the bridge.

### 3.3 Contamination Instruments Used at LANL


#### Contamination Detection Instruments Used at LANL

Contamination	Instrument
Alpha	Ludlum 139 w/ 43-32 RadEye PX w/43-32
Beta/Gamma	ESP-1 w/HP-360
Alpha/Beta	RadEye SX w/43-93



When performing contamination surveys, choosing the correct instrument for the job is critical. An RCT will need to understand what they are surveying to verify all types of contamination are accounted for.

This is especially important when performing release surveys. Using just an instrument that only detects alphas, such as the Ludlum 139, is not sufficient for a free release. This is because it cannot detect other possible types of contamination and does not have the ability to detect activities below P121 Table 14-2, *Surface Contamination Values*.




### 3.4 Surface Contamination Values

#### Surface Contamination Values

Table 14-2 establishes surface contamination thresholds for use in area designation, posting and control, and for item removal from radiological areas, RBAs, and RCAs. This table incorporates 10 CFR 835 and subsequent DOE guidance regarding transuranic values.

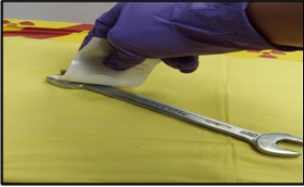
Radionuclide	Removable <sup>2,4</sup> (dpm/100 cm <sup>2</sup> )	Total (Fixed + Removable) <sup>3,5</sup> (dpm/100 cm <sup>2</sup> )
U-natural, U-235, U-238, and associated decay products <sup>6</sup>	1,000 <sup>7</sup>	5,000 <sup>7</sup>
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	100 <sup>10</sup>
Th-232, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above. Includes mixed fission products containing Sr-90. <sup>8,9</sup>	1,000 beta-gamma	5,000 beta-gamma
Tritium and special tritium compounds (STCs) <sup>10</sup>	10,000	See Footnote 6





### 3.5 Types of Contamination


#### Types of Contamination



**Removable**

Removable (loose) surface contamination is easily transferred to personnel or equipment through normal contact.


Removable contamination is measured by a transfer test using suitable sampling material. Common materials used are the standard paper disk smear or cloth smear.



**Fixed**

Fixed surface contamination is not easily transferred through normal contact, and is measured using a direct survey technique (frisking).

Frisking measures both fixed and removable contamination. When non-removable levels are recorded, the loose contamination level must be subtracted from the total.

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### 3.6 Removable - Quantitative

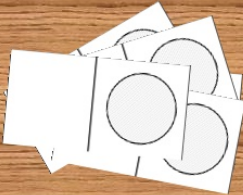
#### Removable - Quantitative


Quantitative surveys are used to determine removable contamination levels. The units of concern for regulatory requirements are disintegrations per minute (dpm) over an area of 100 cm<sup>2</sup>.

This can be obtained by performing a disk smear in an 8 inch 'S' pattern, the size of a dollar bill, or a 4 by 4 inch square. The shape of the smeared area may vary based on the item being surveyed.

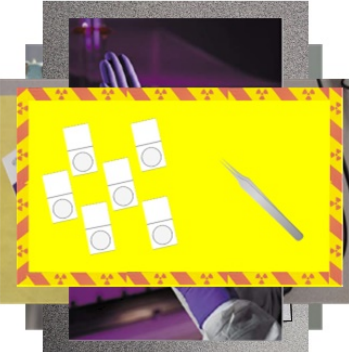
A smear should always be taken in one continuous motion with light to moderate pressure. This should be done in such a way that results are accurate and reproducible.

Survey Type	Survey Parameters	Units
Removable (smear)	Area/Item < 100cm <sup>2</sup>	dpm/smear
	Area/Item ≥ 100cm <sup>2</sup>	dpm/100cm <sup>2</sup>



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### 3.7 Disk Smears



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#### Disk Smears

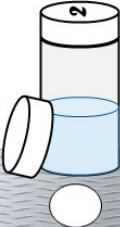
When using disk smears, ensure you perform the following:

- Number the smears
- Wear gloves while performing the survey, even if contamination is not expected
- Survey from lowest to highest potential of contamination
- Treat all used smears as potentially contaminated until verified otherwise
- Separate used smears from clean ones by placing them in a plastic bag
- Perform frequent glove changes and hand surveys to prevent cross contamination

### 3.8 Tritium Smears

#### Performing Smear Surveys for Tritium

- Place an unused tritium smear in sample vial number 1, and mark according to facility processes
- If using 20-mL vials, then prepare each vial by adding 1-mL of deionized (DI) water to each vial
- If using "pony" vials (8-mL to 10-mL), then add 0.5 mL of DI water and 5 mL of UltimaGold/fluor
- Record the blank sample in space number 1 of the survey form
- In one continuous motion, wipe an area approximately 100 cm<sup>2</sup> with the survey media
- Immediately place the tritium smear in a numbered or labeled vial
- Place an unused/blank tritium smear in every tenth vial (e.g., 11, 21)
- Record "blank" on the survey form for unused/blank tritium smears
- If the samples will be sent to HPAL for analysis, then screen/estimate the samples to determine whether HPAL notification or shipping limits have been exceeded



### 3.9 Removable - Qualitative

#### Removable - Qualitative

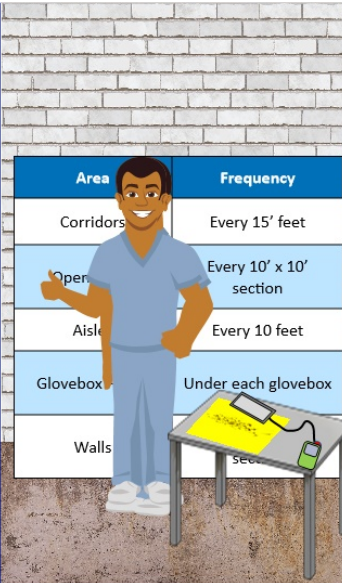
Qualitative surveys are used to determine if contamination is present but cannot be used to quantify the contamination levels (Go/No-Go test). Common materials used for large area wipes are Masslinn cloths.

Large-area swipes (LAS) are used for qualitative surveys and detect any presence of contamination over large areas. These are counted directly with an appropriate instrument to indicate the presence of contamination.


If contamination above MDA/DL is found, follow-up disk surveys should be performed to quantify the contamination.

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Area	Frequency
Corridors	Every 15' feet
Open Areas	Every 10' x 10' section
Aisles	Every 10 feet
Glovebox	Under each glovebox
Walls	See



### 3.10 Large Area Smears



1 South Floor  
2 North hall  
East Floor

#### Large Area Smears

When performing an LAS, the following items should be considered:

- Number the LAS if multiple are taken
- Inspect the mop and replace any old survey material prior to use
- Maintain the same leading edge while performing the survey
- Do not survey the LAS while still on mop due to any potential contamination on the mop giving false indications
- Do not place mop near the face or head due to potential intake of contamination
- Completely open up the LAS to perform the survey, to ensure nothing is missed

### 3.11 Direct Contamination Surveys

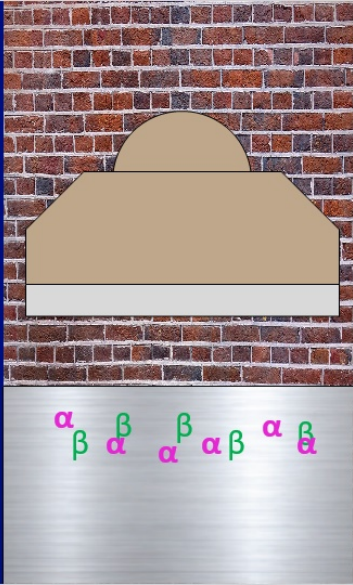
#### Direct Contamination Surveys

Direct surveys (frisks) are performed to get the total contamination of an object, which is the combined fixed and removable levels.

The frisk needs to be performed at a speed of 1-2" per second, and a distance of 1/4" from the object.

This speed is necessary for the detector to have enough time to process the counts that are entering it.

It is important for the detector to be within 1/4" from the object to get an accurate reading. If it is too far away, it will not pick up the short distance traveling alphas.



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### 3.12 Units for Direct Frisking

#### Units for Direct Frisking

Survey Type	Survey Parameters	Units
Direct (frisk)	Detector < 100cm <sup>2</sup> AND area of contamination < detector area	dpm/100cm <sup>2</sup> (no area correction required)
	Detector < 100cm <sup>2</sup> AND area of contamination ≥ 100cm <sup>2</sup>	dpm/100cm <sup>2</sup> (with area correction)
	Detector = 100cm <sup>2</sup>	dpm/100cm <sup>2</sup> (no area correction required)

Direct frisks are recorded in dpm/100cm<sup>2</sup>. As shown in the chart above, there will be times when the detector is smaller than 100cm<sup>2</sup>. In order to account for this, a probe area correction factor will need to be used.

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### 3.13 Probe Correction

#### Probe Correction

If a probe correction is needed to be made, as determined from the chart in the previous slide, the equations below can be used:

$$DPM = CPM \times CCF$$
$$CCF = 1 / \% \text{ efficiency}$$
$$DPM / 100\text{cm}^2 = \frac{DPM}{(X / 100)}$$

CCF = calibration correction factor  
x = probe area (cm<sup>2</sup>)

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**Example:**  
A survey of a desk is performed using a Ludlum 139 with a 43-32 detector. The meter reads a net count of 300 cpm/probe area. What is this in dpm/100cm<sup>2</sup>?

**Givens:**  
Probe area = 76 cm<sup>2</sup>    CCF = 2

DPM = 300 cpm x 2  
= 600 dpm


$\frac{\text{dpm}}{100\text{cm}^2} = 600 \text{ dpm} / (76 \text{ cm}^2 / 100)$

$\frac{\text{dpm}}{100\text{cm}^2} = 600 \text{ dpm} / .76\text{cm}^2$

**= 789  $\frac{\text{dpm}}{100\text{cm}^2}$**


### 3.14 Common LANL Contamination Probes

#### Common LANL Contamination Probes




**Ludlum 43-93**

Probe area = 100 cm<sup>2</sup>  
Detector: Scintillator  
Use: Alpha/Beta



**HP 260**

Probe area = 15 cm<sup>2</sup>  
Detector: Geiger-Mueller  
Use: Alpha/Beta/Gamma



**Ludlum 43-32**

Probe area = 76 cm<sup>2</sup>  
Detector: Air Proportional  
Use: Alpha

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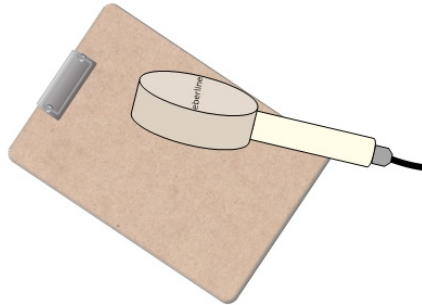
### 3.15 Knowledge Check

(Multiple Choice, 0 points, unlimited attempts permitted)



You perform a direct frisk of a clipboard using a Ludlum 177 with an HP-260 probe. The net counts of the survey read 150 cpm. A CCF of 10 is used for the instrument and a probe area of 15 cm<sup>2</sup>. What is this in dpm/100cm<sup>2</sup>?

☒ 10,000  
☐ 1,000  
☐ NDA  
☐ 15



Correct	Choice
X	10,000
	1,000
	NDA
	15

**Feedback when correct:**

That's right!

$$150 \text{ cpm} \times 10 = 1500 \text{ dpm}$$

$$1500 \text{ dpm} / (15/100)$$

$$= 10,000 \text{ dpm}/100\text{cm}^2$$

**Feedback when incorrect:**

You did not select the correct response.

## Correct (Slide Layer)

You perform a direct frisk of a clipboard using a Ludlum 177 with an HP-260 probe. The net counts of the survey read 150 cpm. A CCF of 10 is used for the instrument and a probe area of 15 cm<sup>2</sup>. What is this in dpm/100cm<sup>2</sup>?

**Correct**

That's right!  
 $150 \text{ cpm} \times 10 = 1500 \text{ dpm}$   
 $1500 \text{ dpm} / (15/100)$   
 $= 10,000 \text{ dpm}/100\text{cm}^2$

Continue

15

## Incorrect (Slide Layer)

You perform a direct frisk of a clipboard using a Ludlum 177 with an HP-260 probe. The net counts of the survey read 150 cpm. A CCF of 10 is used for the instrument and a probe area of 15 cm<sup>2</sup>. What is this in dpm/100cm<sup>2</sup>?

**Incorrect**

You did not select the correct response.

Continue

15

## Try Again (Slide Layer)

You perform a direct frisk of a clipboard using a Ludlum 177 with an HP-260 probe. The net counts of the survey read 150 cpm. A CCF of 10 is used for the instrument and a probe area of 15 cm<sup>2</sup>. What is this in dpm/100cm<sup>2</sup>?

**Incorrect**

That is incorrect. Please try again.

Try Again

15

## 3.16 Contamination Survey Instructions


### Contamination Survey Instructions

**RP-PROG-TP-200, Section 1411.1.1**

- If the area is contaminated, then make appropriate notifications to the HPFC and facility management.
  - [a] Help determine whether the area needs to be decontaminated.
  - [b] After the area is decontaminated, re-survey the area, and evaluate the results to verify successful decontamination.
- If an instrument has an audible feature, then the audible feature must be used.

**NOTE:** Headsets facilitate the use of audible features in high noise areas

- Treat all used smears as potentially contaminated until verified otherwise.

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### 3.17 Contamination Survey Instructions continued

#### Contamination Survey Instructions continued.

- If performing direct and removable contamination surveys together, then perform the direct surveys before the removable.
- Contamination surveys are performed with dry media, even when used on wet surfaces.  
**CAUTION** - All smears must be dry before being counted, except in certain cases for tritium smears
- Releasing an area or facility from contamination or airborne radioactivity status to radiologically controlled area status requires that the area be thoroughly surveyed by radiological control personnel. Contamination must be less than the limits specified in P121 Table 14-2.
- Areas released from contamination status must be decontaminated to a level as far below the allowable release limits as practical.



### 3.18 Contamination Survey Best Practices

#### Contamination Survey Best Practices

##### RP-PROG-TP-200, Section 1411.1.2

- If the contamination type is unknown, then contact an HPFC for guidance on selecting the proper instrument and surveying techniques.
- The following must be considered when performing contamination surveys:

• Characteristics of the radiation hazards	• Potential for contamination
• Size of the area or facility	• Ventilation flow patterns
• Operations conducted in the area	• Contamination history
- Contamination surveys should include enough points to adequately characterize the area being surveyed.
- Contamination surveys should be performed before, during, and at the completion of work, or at any time when a radiological condition change is likely to occur.



### 3.19 Field Screening

#### Field Screening

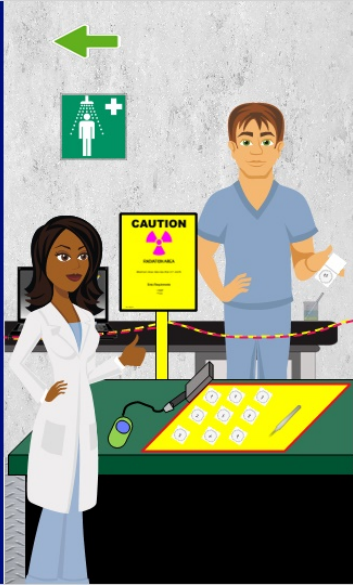
Prior to submitting smear samples a field screen should be conducted.

This is done to verify:

- HPAL notification/shipping limits have not been exceeded
- Postings are sufficient
- RWP suspension limits have not been met
- No abnormalities exist for the scope of work

Due to the accuracy limitations of portable contamination detectors, smears should still be sent to HPAL or placed in a counter (Tennelec/Berthold) following field checks.

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## 4. Documenting Radiological Surveys

### 4.1 Documenting Radiological Surveys

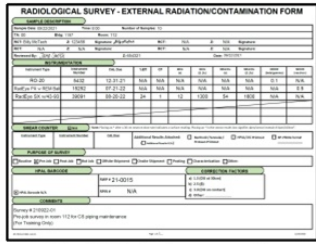
#### Documenting Radiological Surveys

We will now walk through the process for filling out an RP-PROG-FORM-114, *External Radiation/Contamination Form*.

The following video will cover a scenario where a pre-job survey is performed and the field data obtained will be transferred to the survey form.

Reference the survey map shown provided in the link, or from the initial email notification while following along.

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Click on the link above to open survey data

**Start video**

Notes:

